BIOLOGICAL EVALUATION OF WHITE PINE PLANTATIONS ON THE CHIPPEWA AND SUPERIOR NATIONAL FORESTS

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INTRODUCTION

White pine blister rust (Cronartium ribicola) is the most serious disease of white pines in the United States. Historical information on blister rust indicates the disease was introduced into Minnesota in 1916 and reached northern Minnesota in the 1930's. Individual tree mortality can take many years, depending on what age a tree is when infected. Infections which occur early in the development of a seedling are almost always lethal. Infections of older saplings and trees can be lethal, but often kill branches and tops of trees above the point of main stem infection.

Reducing losses to blister rust in the Lake States has focused on planting rust resistant seedlings. Pathological pruning of selected crop trees is also an effective means of reducing losses to the disease (Hagle and Grasham 1988). Planting white pine in Lake States National Forests (with the exception of the Huron-Manistee) has, until recently, been restricted to use of rust resistant seedlings. Seed from trees with putative resistance to blister rust have been produced since 1979 at the Oconto River Seed Orchard, Wisconsin. Since 1983, about 611,000 seedlings originating from the Oconto River Seed Orchard have been planted on Lake States National Forests.

A survey conducted in 1984 of natural white pine regeneration on the Hiawatha National Forest, showed an average infection rate of 1.5 percent (Robbins and Jackson 1984). This was unexpectedly low, based on previously developed hazard zones (Van Arsdale 1964). This fact, together with similar observations elsewhere, created an increasing interest in planting white pine on National Forests in the Lake States.

Research has shown that soils, climatic conditions (hazard zones), topography, and stand conditions are important considerations in selecting sites for planting white pine (Robbins 1984). The Chippewa and Superior National Forests are in hazard zones 3 and 4, moderate and severe risk areas for blister rust.

Based on basidiospore challenges performed at Oconto River, it is estimated that 25 percent of seedlings produced since 1983 are potentially resistant to blister rust. The manifestations of resistance range from no successful infections to rapid dehiscence of infected needles to relatively slow progression of disease in infected seedlings. This survey of Superior and Chippewa National Forest white pine plantations was conducted in May and June of 1989 to evaluate levels of blister rust infection and the general condition of planted seedlings. Natural white pine regeneration in the vicinity of plantations was similarly evaluated.

OBJECTIVES

Surveys were conducted in 3-8 year old plantations and in stands with natural regeneration 3-10 years old. The objectives of the survey were:

1. To estimate the numbers of seedlings per acre,
2. To estimate the percent of live seedlings infected by blister rust,
3. To quantify the extent of other insect and disease problems affecting plantations,
4. To develop recommendations on the management of white pine plantations.

METHODS

The Chippewa and Superior National Forests provided maps and locations of all rust-resistant white pine plantations established in the years 1983-1985, and known areas of natural regeneration. Three plantations on the Superior were established in 1981 using containerized seedlings grown from Oconto seed. Each plantation was surveyed starting 60 m into the plantation. Observations on seedlings were made in .008 ha circular plots (1/50 ac, 16.65 ft radius), at 60 m intervals, along lines running across drainages, until the entire plantation was surveyed.

Data collected at each plot were: Associated vegetation (i.e. grass, brush, tree cover), the number of live white pine seedlings, the number of live seedlings infected by blister rust, and the presence of other pest damage.

RESULTS

Chippewa National Forest

Seventeen plantations and three areas of natural regeneration were surveyed. Blister rust incidence ranged from 0-41 percent (average = 9.4 percent). Seven plantations had no detectable blister rust. Six of the seven were planted in 1983, the seventh in 1986. The mean height of the seedlings in these plantations was 16.4 inches. Severe and repeated browse damage is responsible for the poor performance of these seedlings, and probably for the absence of detectable levels of blister rust, since little or no new growth is ever available for infection by rust basidiospores. In fact, deer browse was the most widespread and serious problem in most plantations. About 45 percent of all seedlings were browsed.

An average of 9.4 percent of surviving seedlings in plantations with detectable levels of rust were infected. The infection rates for all plantations with detectable levels of blister rust ranged from 0.66 - 6.8 percent per year (average percent infection per year = 3.08 percent).

Adelgid (Pineus strobi), weevil (Pissodes strobi) and mechanical damage were only important in localized instances. Survey data are summarized in table 1. Because of limited sampling of natural regeneration areas and the high mean standard error associated with pest incidence, little inference can be made about any differences between plantations and natural regeneration areas. Confounding factors of age, site and particularly browse damage, makes any analysis of relative rust resistance invalid.

RESULTS

Superior National Forest

Eight plantations and three areas of natural regeneration were surveyed. Blister rust incidence ranged from 5-46 percent (average = 16 percent). All plantations and natural stands were infected by blister rust. As on the Chippewa, deer browse was the most serious problem affecting seedlings. About 27.5 percent of all seedlings were browsed.

An average of 16 percent of seedlings per plantation were infected by rust. The blister rust infection rates ranged from 0.63 - 10 percent per year (average percent infection per year = 3.05 percent).

Adelgid levels were slightly higher than on the Chippewa, as was the incidence of weevil. Mechanical damage was widespread in both plantations and natural regeneration areas. Many seedlings had been uprooted, either planted too shallowly, yanked out or frost heaved. Survey data are summarized in table 2.

As with the Chippewa, little inference can be made about any differences between plantations and natural regenerations areas. Similar confounding effects preclude analysis of the relative rust resistance of planted and natural regeneration.

Table 1. Chippewa Survey Summary (251 acres, 20 plantations)

District	Comp #	Std #	Haz Zon	Year Orig	Seedlings Per Acre	$\bar{X}$ Ht"	Assoc Veget	% w. Ribes	Stem Rust Per Acre	Branch Rust Per Acre	Total Rust Per Acre (%)	Browsed /Ac (%)	Adelgid /Ac (%)	Weevil /Ac (%)	Mech Dam* /Ac (%)
Marcell	55	29	3	83	514	47	grass	44	81	75	156 (30)	139 (27)	25 (5)	0	0
Deer Riv	141	3	4	83	375	38	grass	20	20	45	65 (17)	105 (28)	35 (9)	105 (28)	20 (5)
Deer Riv	256	56	4	83	179	12	grass	0	0	7	7 (4)	72 (40)	7 (4)	0	0
Deer Riv	20	1	4	83	288	15	grass	15	27	12	39 (14)	150 (52)	0	0	0
Deer Riv	78	22	4	83	250	31	NoHrd	17	38	17	55 (22)	55 (22)	17 (7)	0	0
Cass Lk	8	1	4	84	142	18	grass	79	8	0	8 (6)	55 (39)	5 (4)	0	0
Cass Lk	86	20	4	86	325	13	grass	67	0	8	8 (2)	0	0	0	0
Cass Lk	77	15	4	83	493	37	grass	43	136	64	200 (41)	138 (28)	14 (3)	0	0
Cass Lk	87	34	4	86	209	9	NoHrd	0	5	0	5 (2)	42 (20)	0	0	0
Cass Lk	62	21	4	84	495	24	NoHrd	18	55	55	110 (22)	84 (17)	41 (8)	0	0
Bl Duck	89	14	4	83	400	15	grass	0	0	0	0	55 (14)	0	9 (2)	0
Bl Duck	129	48	4	83	75	8	grass	38	0	0	0	6 (8)	0	0	0
Walker	88	66	4	83	386	26	grass	57	0	0	0	371 (96)	0	9 (2)	0
Walker	168	8	4	83	371	14	grass	100	0	0	0	356 (96)	7 (2)	0	0
Walker	179	42	4	83	562	29	grass	31	0	0	0	528 (94)	21 (4)	21 (4)	0
Walker	155	29	4	83	217	14	grass	0	0	0	0	217 (100)	0	0	0
Walker	60	6	4	86	454	9	grass	0	0	0	0	368 (81)	0	0	0
TOTALS	17										MEANS 9.4%	44.8%	2.7%	2.1%	.7%
Natural Regeneration Areas															
Marcell	55	-	3	-	93	87	NoHrd	0	0	0	0	0	0	0	0
Walker	25	-	4	-	625	98	pine	0	0	0	0	0	0	0	0
Cass Lk	131	12	4	-	400	84	grass	0	0	100	100 (25)	0	0	25 (6)	0
TOTALS	3										MEANS 8.3%	0	0	2%	0

* See Table 2 footnote for an explanation of table heading abbreviations.

Table 2. Superior Survey Summary (200 acres, 13 plantations)

District	Comp #	Std #	Haz Zon	Year Orig	Seedlings Per Acre	$\bar{X}$ Ht"	Assoc Veget	% w. Ribes	Stem Rust Per Acre	Branch Rust Per Acre	Total Rust Per Acre (%)	Browsed /Ac (%)	Adelgid /Ac (%)	Weevil /Ac (%)	Mech Dam /Ac (%)
Laurent	356	14	4	86	167	8	grass	100	50	0	50 (30)	142 (85)	0	0	0
Laurent	354	31	4	86	170	18	grass	0	15	3	18 (11)	73 (43)	8 (5)	0	23 (14)
Tofte	152	17	4	86	405	37	grass	0	20	5	25 (6)	134 (33)	50 (12)	5 (1)	50 (12)
Isabella	42	52	4	86	264	17	grass	18	5	9	14 (5)	5 (2)	9 (3)	0	14 (5)
Isabella	281	15	4	83	386	52	birch	64	114	64	178 (46)	0	0	9 (2)	86 (22)
La Croix	129	2	3	81	407	63	grass	0	36	21	57 (14)	28 (7)	43 (11)	64(16)	64 (16)
La Croix	103	27	3	81	281	52	grass	13	13	0	13 (5)	67 (24)	19 (7)	56(20)	44 (16)
La Croix	78	28	3	81	238	37	grass	50	13	13	26 (11)	62 (26)	88 (37)	13 (5)	63 (26)
TOTALS	8									MEANS	16%	27.5%	9.4%	5.5%	13.9%
Natural Regeneration Areas															
La Croix	208	7	3	-	210	20	aspen	0	20	0	20 (10)	69 (33)	0	0	60 (29)
Isabella	205	-	4	-	278	44	pine	0	0	11	11 (4)	78 (28)	94 (34)	39(14)	89 (32)
Isabella	20,22	-	4	-	1184	33	pine	0	34	9	43 (4)	12 (1)	81 (7)	0	144 (12)
TOTALS	3									MEANS	6%	20.7%	13.7%	4.7%	24.3%

*District - Abbreviation for district name, Comp - Compartment number, Std - Stand number, Haz zon - Blister rust hazard zone, Year orig - Year in which the plantation was established, Seedlings per acre - the number of live white pine seedlings per acre, $\bar{X}$ Ht" - mean height of seedlings in inches, Assoc veget - predominant associated vegetation or overstory if present, % w. Ribes - Percent of .02 acre plots in a plantation where Ribes sp. was present, Stem rust per acre - Seedlings with rust infections on the main stem, Branch rust per acre - Seedlings with rust infections on at least one branch, Total rust per acre (%) - Sum of stem and branch infections (% of seedlings per acre), Browsed /ac (%) - Seedlings per acre that were browsed (% of seedlings per acre), Adelgid /ac (%) - Seedlings per acre infested with Pineus strobi (% of seedlings per acre), Weevil /ac (%) - Seedlings per acre infested by Pissodes strobi (% of seedlings per acre), Mech Dam /ac (%) - Seedlings per acre trampled or otherwise mechanically damaged (% of seedlings per acre)

DISCUSSION AND RECOMMENDATIONS

The general condition of most plantations is poor to fair. Repeated deer browse injury is probably the greatest limiting factor in plantation establishment. Some type of deer control measures must be implemented if the plantations are to succeed.

The extent and intensity of deer damage undoubtedly confounded observations of blister rust and weevil incidence. Since new growth and terminal leaders are browsed by deer, this probably reduces the incidence of both blister rust and weevil. Except for a few plantations, weevil incidence was not important, even though most plantations were large, open field plantings. However, plantations were not yet the optimum age and size for maximum susceptibility to weevil attack.

Since both the Chippewa and Superior National Forests are in hazard zones 3 and 4, more consideration must be given to proper site selection and corrective pruning, where weevil damage is limiting, and pathological pruning to prevent and control blister rust where appropriate.

Nicholls and Anderson (1977) developed guidelines for selecting plantations where pathological pruning would be appropriate. Depending on the number of crop trees, acceptable annual rates of infection are as follows:

White pine Per Acre	Acceptable Annual Rate of Infection
200-299	1 %
300-399	2 %
400-499	3 %

Three plantations on the Chippewa and one on the Superior qualify for pruning under these guidelines. Several additional plantations are marginal based on these guidelines and should be also be considered for pruning. Tables 3 and 4 summarize the stocking and infection rate data.

Table 3. Chippewa Plantations

Plantation	Prunable Trees	Annual Infection Rate[a]
Marcell 55	433	3.46[b]
Deer River 141	355	2.54[b]
Deer River 256	179	.78
Deer River 20	261	.92
Deer River 78	212	1.60
Cass Lake 8	134	0
Cass Lake 86	325	.49
Cass Lake 77	357	3.59[b]
Cass Lake 87	204	0
Cass Lake 62	440	2.50

a - See Table 4 footnote to see how this is calculated.
b - Plantations that exceed acceptable rates of annual infection.

Table 4. Superior Plantations

Plantation	Prunable Trees	Annual Infection Rate[a]
Laurentian 356	117	0
Laurentian 354	155	.39
Tofte 152	385	.26
Isabella 42	259	.70
Isabella 281	272	4.71[b]
La Croix 129	371	1.13
La Croix 103	268	0
La Croix 78	225	1.16

a - Annual infection rate is calculated as follows:

(Trees with branch cankers per acre) divided by (seedlings per acre minus trees with stem cankers per acre) divided by 5 (years).

This means the number of trees with stem cankers are ignored in calculating annual infection rates to see if pruning is appropriate. In other words, trees infected before 5 years ago are not considered prunable or crop trees. The actual annual infection rates are, therefore, higher in all cases.

b - Plantations that exceed acceptable rates of annual infection.

Clearly factors other than blister rust are vital to consider when attempting to cultivate white pine. Site and cultural factors are perhaps even more important than planting seedlings with putative resistance to blister rust.

It is essential to thoroughly evaluate rust resistance of Oconto River Seed Orchard stock by growing them together with unimproved seedlings under field conditions. Demonstration plantings such as the administrative study undertaken between the Hiawatha National Forest, NCFES and FPM, should be installed throughout high hazard zones. It is also clear from this survey that it will be imperative to protect these demonstration plantings from deer damage and other confounding factors if the actual rust resistance of Oconto River seedlings is ever to be ascertained under field conditions.

LITERATURE CITED

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